Exploring Engineering Challenge:

Water Cleaning

ROCHESTER BRIDGE TRUST

About the Rochester Bridge Trust

The first bridge at Rochester was built by the Romans soon after the invasion of Britain in AD43. Once the Romans left, their bridge was maintained by the local people of Kent until the 14th century. In 1381, the River Medway froze solid and, when the thaw came, the ice and floodwater swept away the Roman Bridge.

Two benefactors built a new stone bridge one hundred yards upstream which was opened in September 1391. Their names were Sir John de Cobham and Sir Robert Knolles. Together the benefactors also persuaded their friends and acquaintances to make donations of land and money for the perpetual maintenance of Rochester Bridge. In 1399, King Richard II granted letters patent which allowed the Rochester Bridge Trust to be set up to care for the bridge and its property. Two Wardens were appointed to manage the bridge.

For the next 457 years, the Wardens looked after the medieval bridge. Major improvements were carried out by the civil engineer, Thomas Telford, in 1827. However the increase in road and rail traffic as a result of the industrial revolution meant the stone bridge's days were numbered.

In 1856, the Trust completed a new cast-iron arch bridge on the line of the original Roman Bridge. It was designed by Sir William Cubitt who had been the civil engineer for the Crystal Palace built for the Great Exhibition in 1851. The old medieval bridge was then blown up for the Wardens by the Royal Engineers using gunpowder.

The Victorian Bridge was reconstructed in 1914 as a bowstring truss and is today known as the Old Bridge. A second road bridge, the New Bridge, was opened to traffic in 1970. Between the two road bridges there is the Service Bridge which carries pipes and cables across the river.

The Rochester Bridge Trust is a registered charity and still owns and maintains the two road bridges and the Service Bridge free of charge to the public. The Trust's money is derived from the land and money given by the benefactors in the 14th and 15th centuries. It receives no public money, does not charge tolls and does not raise funds. With any surplus funds, the Trust supports other charitable projects, primarily the preservation of historic buildings and education projects in the field of engineering, particularly civil engineering.

How to use this book

This book includes a copy of all of the resources you will need for running the challenge for your learners. The resources are designed for a class of 30-32 learners.

There are PowerPoints (with explanatory notes) to explain the 'pre tasks', as well as the Challenge itself. The pre tasks are designed to develop the skills and knowledge needed to complete the Challenge. The notes on each slide explain what you would say and the points to draw out of the learners through questioning and hands-on activities.

If you wish to use these as a presentation, they will need to be downloaded as an electronic copy (links are included at relevant points). All downloads are free of charge. Some resources will need to be reproduced for learners to use: you can either photocopy directly from the book, or again, download the PDFs using the links.

This pack includes:

1. a document that gives guidance on how to structure and deliver the tasks for the challenge leader(s);
2. an equipment list for the challenge, allowing you to print one list of everything you need, listed in the order of the sessions;
3. the testing rig working drawing for making up the testing station, including a technical drawing and cutting list;
4. the pre tasks on PowerPoint (with notes), broken down into two pre tasks to enable them to be used for shorter twilight sessions. Within an hour, it should be possible to complete one of the pre tasks, with sufficient time for the children to clear up and pack away after;
5. Pre task 1 joining materials handout
6. Pre task 2 6mm mesh
7. Pre task 2 water filter team cards
8. Pre task 2 water clarity table
9. Pre task 2 OPALometer
10. Pre task 2 test log
11. 'The Challenge' on PowerPoint (with notes);
12. 'The Challenge' guidance for learners;
13. a sheet of the Rochester Bridge Trust logo for printing. This can be cut up into separate logos.
14. Testing notes and a log to help document the results;
15. 'Water Cleaning Challenge' certificate for learners completing the challenge
16. a risk assessment template with suggested risks for the challenge. (Please note, this is not extensive and each Challenge leader should undertake a full risk assessment for their individual setting.)

How to use this book

There are different ways in which you can use this Exploring Engineering Challenge, based on the circumstances in your location. It has been designed to be suitable for 8-11 year olds and could be delivered as:

- a whole day, with one class in a primary school, in a classroom or hall;
- two half days, with one class in a Primary School, in a classroom or hall;
- four twilights, with one class in a Primary School, in a classroom or hall (a twilight would tend to be about an hour, however where possible, negotiate slightly more than an hour to allow for arrivals and packing away e.g. 15.15 – 16.30);
- alternatively, you could scale it up to work with many teams or scale it down for use at home or in a club.

How to use this in your school:

Some schools will recognise the term STEM (Science, Technology, Engineering and Maths) and be keen to have support to enrich their STEM learning. This is a STEM Learning Day and can form part of your enrichment days.

These resources are aimed at children in Key Stage 2 and especially sit within the Year 5 Science Curriculum. You may also want to use it with Year 6 children, after their SATs have been completed.

National Curriculum Mapping:

This Challenge maps to the National Curriculum Programmes of Study as follows:

Design & Technology: the whole concept of the Exploring Engineering Challenge is design process in action. It encourages children to design something, for someone, for a specific purpose.

KS2 (8-11 year olds): Design, Make and Technical Knowledge Criteria.

Maths: KS2 (8-11 year olds): 'Number and Place Value', 'Addition and Subtraction', 'Measurement', 'Geometry – Properties of Shapes'.

Science: KS2 (7-11 year olds): 'Living Things and their Habitats', 'Uses of Everyday Materials', 'Properties and Changes of Materials' and 'Forces'.

Using the Resource in a Club or at Home:

Of course, this material could be used with a local community group/club, e.g., "Guides and Scouts, or home education groups, and families. All you need to do is to adapt the quantities of materials you need.

And finally... Enjoy this! It's easy to get started, with just one child or class.

Resources

1. **Leaders' guidance**

   This document provides guidance on how to structure and deliver the tasks. It is an essential guide and contains the same notes included in the digital PowerPoint presentation. As a challenge leader you can use this as a reference document.

2. **Equipment list**

   This document lists all the materials and tools you need to run this challenge, listed in the order of the sessions, sufficient for one class of 30-32 students, whether structured as a single day, or split into shorter sessions.

3. **Test rig working drawing**

   This document includes a Technical drawing with cutting list for making the test rigs.

4. **All pre tasks PowerPoint**

   These slides guide your group through the creative pre tasks. These hands-on pre tasks provide them with vital learning to help them make the most of the challenge. The digital version has notes for your guidance for each slide.

   Please adapt the colour of the background to suit your projection equipment so it is not too white.

5. **Pre task 1 testing materials handout**

   A copy of this document is needed for each team so they can log their test results in pre task 1.

6. **Pre Task 2 6mm mesh**

   This document can be copied and then laminated to provide a visual aid for class to see how small a 6mm mesh is.

7. **Pre Task 2 water filter team cards**

   This document can be copied and cut up into team cards. It tells each team what they need to use to ensure there is a variety of tests across the group.

8. **Pre Task 2 water clarity table**

   This document provides a guide for measuring water clarity when using an OPALometer.

9. **Pre Task 2 OPALometer**

   This document can be copied, cut out and laminated to make waterproof OPALometers, with the additional information offering guidance on how to make and use an 'OPALometer' (water clarity measurer).

   Thank you to www.OPALexplorenature.org for making this freely available for use.

10. **Pre Task 2 test log**

    This document provides a simple way for you to record results from your pre task 2 tests.

11. **The Challenge PowerPoint**

    These slides guide your group through the actual engineering challenge.

12. **The Challenge guidance for learners**

    This guidance for learners can be copied and provided to teams as a reminder of what they need to do and the criteria they are working towards.

13. **Logo samples**

    This document includes multiple copies of the Rochester Bridge Trust logo and can be copied and cut up individually for each team to use in the challenge.

14. **The Challenge testing notes**

    These notes offer guidance on carrying out the testing itself

15. **The Challenge test log**

    This document provides a simple way for you to record results from the final whole group challenge.

16. **Certificate**

    This is suitable for each participant and can be presented as part of your results ceremony at the end of the challenge.

17. **Risk assessment template**

    A starting point for the challenge leader(s)' own risk assessment for their setting. Please note, this is not extensive and should only be used as guidance.

All of the above documents can be downloaded here: http://www.rochesterbridgetrust.org.uk/exploring-engineering/exploring-engineering-challenges/water-cleaning/

Leaders' guidance

1. **Introduction**

   What is Civil Engineering? How does it make a difference (including Civil Engineering roles)?

   How engineers design and model things that help balance forces.

2. **Pre task 1**

   Explore how to effectively join materials while considering how to make them stronger, bearing in mind the forces at work around them.

3. **Pre task 2**

   Learn how engineers design ways to clean water; experiment and predict using a simple water filtering system.

4. **Challenge**

   Apply everything discovered so far to design and model a water filtering system to fit on a simple test rig, which transports the water to another place for testing.

Most of the guidance you need can be found on the notes section under each PowerPoint slide, which can be printed, or used with 'presenter view' when displaying the slideshow.

Introduction to Civil Engineering

There are many different types of engineers. In this challenge, learners are going to explore a range of engineering roles, including civil engineers. Very often, people are not aware of civil engineers, and don't understand what they do, but their work is all around us. Civil engineers design the BIG things that make our lives easier. They design water treatment plants, so that we can flush the toilet and get washed in the morning. They design roads but not cars, harbours but not boats, airports but not planes, stations but not trains. They build the big stuff that makes our lives flow more easily.

Whilst designing these large one-off structures, teams of different engineers must work together and this is what you are going to be doing today. But, what does it mean to work in a team? What different types of engineers might work together in a team to design something like an airport, bridge or rollercoaster? What do you think each type of engineer does within the team?

Civil Engineers – choose the best designs for the job, they call this design 'fit for purpose';

Structural Engineers – work out how the shapes of materials might fit together, to look right and fit together properly;

Materials Engineer – work out what types of materials to use and whether they are strong, flexible, rigid or soft enough; and

Value Engineer – work out how to make the design better value for money. For example, if builders use 1mm less concrete all over a structure, will it save money? But, they also have to make sure if they use less concrete, that the design is still safe.

Civil Engineers have an important job to do to make our lives flow more easily. One of the things they have to think about when designing big things are the forces which will affect their designs. They have to balance the forces and consider the loads that must be supported by the structure. Without doing so, structures could fail and not be fit for purpose.

When designing a structure, the mass of the structure itself is called the 'Dead Load'. Ask students "What could affect the size of this load?" The amount of material in it, the design, the material that it is made from. "What is the impact of having a large Dead Load?" Too many materials = cost, time to build; impacts the remaining amount of load the structure can support.

"What do you think we mean by 'Live Load'?" This is a combination of the users of the structure, for example, vehicles and/or pedestrians crossing a bridge, as well as environmental factors, such as wind, or even snow. "When engineers design large structures, they must think about not just the size of the Live Load, but also the fact that it is moving – what is the impact of the load moving across a bridge?" Encourage students to think about the position of the load and the effect this might have.

Two effects of forces which engineers have to think about are tension and compression. Tension is a stretching force and compression results from two forces opposing each other, creating a squashing effect. If the pulling force/tension is greater in one direction than another, the forces aren't balanced and the structure will pull in that direction, which may lead to collapse. To stay up forces need to be equal/balanced. The same for compression, the pushing force on each side needs to be balanced to keep it upright and not fall over. In the presentation, there is a demonstration of tension and compression involving participation from the learners. You could invite learners to try this, just make sure they know they are not trying to make each other fall over, they are trying to balance and also clear the area so they can't knock into anything if they do fall.

Leaders' guidance

Pre task Guidance

Pre task 1a and b – Learning to Join Materials

Different materials have unique properties – "properties" means "what something is like or what it can do". The properties that a material has can make it good for a particular function or job.

For example, a toilet roll is quite strong in compression if you hold it vertically and push it from above, but if you lay it horizontally and push from above it squashes really easily. So, it is strong in compression one way, but not another.

String, in comparison, is wobbly and floppy and doesn't have high compressive strength (it can be squashed easily). However, if pulled tight, it has very high 'tensile' strength.

Therefore, the materials which we select for a particular function will depend on the properties we need them to have.

The main focus here is helping the learners experiment with joining materials together using cable ties, string, elastic bands and double sided tape, whilst making a tower. The experimentation is more important than the outcome. This is especially important if those you are working with have not had much experience of making and junk-modelling.

Do demonstrate how to use double sided tape by joining materials together inside a join rather than around the outside. It is unlikely the learners will have had the opportunity to use double sided tape before.

Explain that later in the challenge, they will gain extra points for using double-sided tape correctly.

Encourage learners to recognise certain structural features that might be relevant to their designs. For example;

- Wide bases of piers and pylons;
- Secure foundations;
- Using tubes and cross-struts;
- Triangular structures.

Pre task 2 - Water Clarity Testing

In this task the learners will observe the effect of differing quantities of material (sand, grit, stones) in their filter. For example, if they have more stones it could flow more quickly, but not clean so well. If they have more sand it might clean better, but take longer.

This task will help them start to decide for themselves how much of each material to use.

Testing the filters

To help keep the potential mess with water and soil contained, it's worth following these steps. It also helps having two adults run tests at the same time. To test the filters:

1) place the washing up bowls at the front of the room to create testing areas;

2) for each test, mix 2 dessert spoons (roughly) of soil into 100ml water, in a plastic pint glass. This mixture will be poured through each team's filter funnel;

3) for each team, put an OPALometer into the bottom of a cereal bowl and place into the washing up bowl, situated in the testing area;

4) an adult should pour the entire volume of soil-mixed water through the filter and set the timer for 90 seconds to allow for filtering;

5) after 90 seconds of the water dripping through, put the filter into a plastic pint glass so it stays upright and collects the drips. You could ask a child to oversee the timing with a stop watch;

6) lay out the bowls across the front of the table in team order, from team 1-8, so they can be compared at the end;

7) look through the water in the cereal bowl to the OPALometer at the bottom to check the water clarity. You could do an overall comparison between bowls and draw a general conclusion about which team's quantities seemed to work best. If you have more time, you could use the clarity table to ascertain whether the clarity is poor, average or very good. (For further guidance on the OPALometer and how it can be used in other settings, see section 9);

8) record the results for each team on a copy of the pre task 2 test log

Leaders' guidance

Summarising findings

This is a time to encourage the learners to think about the different quantities of materials that filtered best in terms of water clarity and speed. NB: in trials, it seemed the filters with equal amounts of each material cleaned best.

In terms of speed, you can compare how much water there is in each bowl at the end of 90 seconds, using measuring cylinders to measure the volumes. The bowl with the most water filtered most quickly.

You can also ask the learners whether we have filtered enough to make the water drinkable. This might make them laugh and get them quite engaged. Encourage them to think of contaminants that you can't see as well as those you can. Ask them what else has to happen in a real water treatment works before water can be drunk again.

Challenge Guidance

The learners have now been given enough information which they can apply to the Challenge.

Introducing the Challenge

1) In the room, you will need to ensure that:

   a) each team has a table or work space in which to complete the challenge

   b) testing areas at the front of the room, accessible for learners to use as a resource during their construction phase, as well as for the testing phase

   c) if possible, a cutting mat and Stanley knife will be accessible to learners, but (age dependent) an adult will need to use the knife to cut materials to size

2) each team should be provided a copy of the Challenge guidance for learners on their tables

3) explain the following Health & Safety rules:

   i. do not run in the room;

   ii. pick things up off the floor that people might slip on;

   iii. tie back long hair;

   iv. hold scissors safely and instruct them not walk around the room with them.

Using Test Rigs

Explain that the learners are allowed to come up in teams to explore and measure the test rig, but only a few minutes at a time. NB: if they don't have a whole test rig each, then it is easier to ration the time and it is also easier to ensure they design something that is fitted not fixed.

Questions from Learners

When the learners ask for help, you can prompt them with things they have learned in the pre tasks, or refer to their guidance sheets on their tables.

Structuring the Challenge Time

The groups are likely to need a reminder every 10-15 mins what they should be doing to keep them on task. This can include reminding them about:

- comparing ideas and combining the best parts of each person's design into a final design;
- having everyone involved, if you don't have a job to do you can be designing the decoration as points are awarded for this during testing;
- remind them how much time they have left;
- give them a last 5 minutes warning at the end;

At the end, tools are to be put down and tidied away into packs, scraps to be put in the bin and, finally, to sit down ready for testing.

Make sure you leave 40 minutes for testing and awarding certificates and prizes.

Leaders' guidance

Context:

You are members of a team of environmental civil engineers working for Rochester Bridge Trust. You have been asked to design and model a water filter system. Your water filter needs to be the right size and sit in the right place for the water to be collected in one place and then travel to be used in another place.

Brief:

Your challenge is to design, scale model and test a water filter system which will release its water 20cm above the ground (2 metres in real life) and fit over the guttering provided. The water will then be collected and tested.

Specification:

1. The water filter and structures you model must be fitted not fixed.
2. The filter must be raised to at least 20cm off the ground and be supported to sit over the left hand side of the guttering, allowing the water to flow down for collection.
3. The filter must flow quickly enough to collect sufficient water for testing in 90 seconds.
4. The water must be cleaner than it was to start with, using an Opalometer for testing.
5. The filter and its structure must promote its designers – the Rochester Bridge Trust.

(You will also get bonus points for using the materials appropriately)

A simple portfolio must be produced as part of your design and planning and should include:

1. All labelled drawings.
2. Notes on how your team is being organised.
3. Notes/labels on how ideas were thought of and developed.
4. Notes about the challenges you have overcome.
5. Reasons for choosing the final design.

Plenary of the Learning

The beginning and end of the event will be most memorable to learners, so do help them to summarise what they have learnt today. You may need to draw out the learning while the water is filtering rather than at the end if time is getting tight.

A certificate has been included within this book: this is suitable for each participant and can be presented as part of your results ceremony at the end of the challenge. The participants will be very excited by simple prizes like lollies or erasers (in the trials, we gave everyone a poop emoji eraser).

Equipment list

Listed below is everything you will need for one group of 32. Please adjust the list according to the group you are working with.

For each session:

- AV equipment for presentation and presentation on USB stick, extension lead;
- Class set of "Civil Engineers Make My Day" postcards (available from Rochester Bridge Trust, request the quantity you need from: education@rbt.org.uk);
- a room with tables, chairs etc.;
- a risk assessment for the space and learners in your setting.

Tool Kit used for the whole day:

Per team	For a group of 32 in 8 teams:
Zip lock bag to store:	**8x zip lock bags to store:**
1 x pair large scissors	8x pairs large scissors
1 x large hole punch	8x large hole punches
1 x reel easy peel double sided tape	8x reels of easy peel double sided tape
1 x dessert spoon	8x dessert spoons

Optional: scissors, pencils, coloured pens and rulers

Pre task 1 Joining Materials:

- Toilet roll inner tube and ball of string for tension and compression demonstration.

Per team	For a group of 32 in 8 teams:
1 poly pocket to store these items:	**8 poly pockets:**
2 x 1000mic grey card A5	16 x 1000mic grey card A5
2 x 1500mic grey card A5	16 x 1500mic grey card A5
0.5m string	4m string
2 x cable ties	16 x cable ties
2 x elastic bands	16 x elastic bands
2 x wooden kebab or candy floss sticks	16 x wooden kebab or candy floss sticks
1 x Pre task 1 testing materials handout	8 x Pre task 1 testing materials handout

Teams also need the tool kit each, as listed above.

Equipment list

Pre task 2 Cleaning Water:

- copy of the 6mm mesh document (as a visual aid);
- sediment sample – 1 clear plastic cup with water and soil stirred in that has started to settle as session progresses;
- pre task team cards – printed and cut so one for each team;
- a tool kit (listed above) per team;
- NB: dessert spoon is used as a measure for the quantity of materials throughout the pre tasks and challenge itself: the actual size of the spoon isn't an issue, as long as all spoons/quantities of material are the same size.

Per team	For a group of 32 in 8 teams:
1 large funnel	8 funnels
3 clear plastic cups containing:	24 clear plastic cups containing:
sand	small bag of sand
grit	small bag of grit
small stones/pebbles	small bag of small stones/pebbles
2 dessert spoons for measuring out	16 dessert spoons for measuring out
coffee filter paper	8 coffee filter papers
2 sheets A4 plain paper	16 sheets A4 plain paper
	Dust pan and brush (in case of spills)

Testing for pre task 2:

- 2 washing up bowls;
- compost in sealed box (at least 2 dessert spoons per team);
- 2 dessert spoons for measuring out;
- bottle of water or access to water in classroom;
- 8 plastic pint cups with 100ml water in them;
- 8 white cereal bowls;
- measuring cylinder(s);
- kitchen roll (in case of spills);
- stop watch, stop clock or 90 second timer/sand clock batteries;
- 8 laminated copies of OPALometer discs and Measuring Water Clarity Tables;
- one copy of the Pre Task 2 Test Log to record results.

Equipment list

The Challenge:

- AV equipment, USB stick with the presentation etc.;
- a room with tables, chairs, set for 8 team areas;
- 32 pieces of A4 paper (one for each learner);
- Each team needs the toolkit with scissors, hole punch, tape and spoon (as listed above).

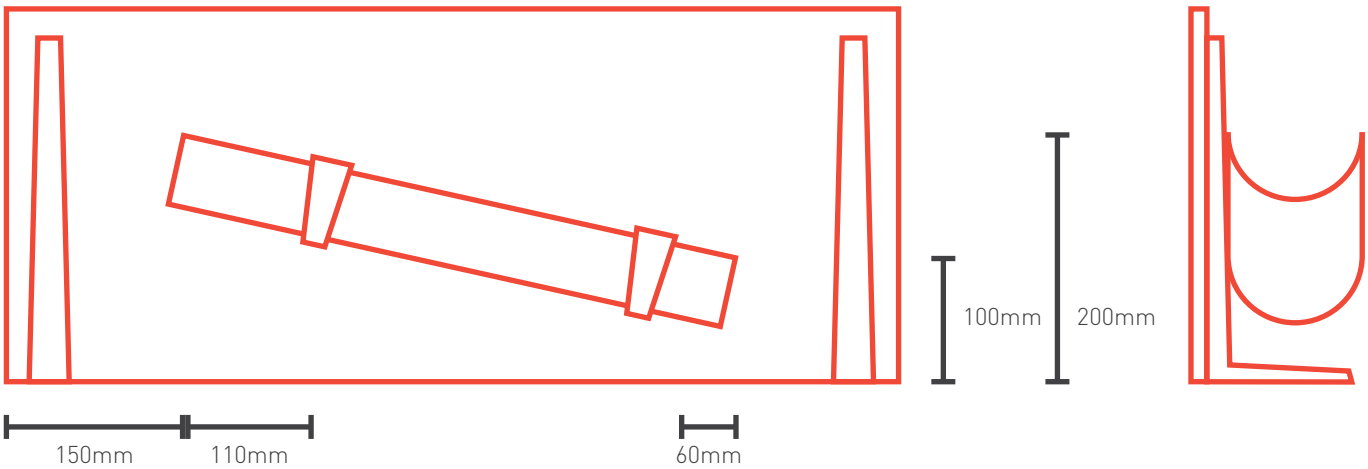
Per team	For 32 in 8 teams:
1 copy of The Challenge guidance for learners	8 copies of The Challenge guidance for learners
1 large funnel	8 funnels
3 plastic cups:	24 plastic cups:
cup of sand	8 cups of sand
cup of grit	8 cups of grit
cup of small stones/pebbles	8 cups of small stones/pebbles
coffee filter paper	8 coffee filter papers
2 x 1000mic grey card A3	16 x 1000mic grey card A3
2 x 1500mic grey card A3	16 x 1500mic grey card A3
1m string	8m string
6 cable ties	48 cable ties
6 elastic bands	48 elastic bands
8 wooden kebab or candy floss sticks	64 wooden kebab or candy floss sticks
1 logo	8 logos
glue stick	8 glue sticks
	Safety rule
	Stanley knife
	A3 cutting mat

Equipment for testing:

- at least 2 test rigs per group;
- compost in sealed box;
- dessert spoons for measuring out;
- measuring jug for water (or mark 100ml on the plastic pint cups);
- bottle of water or access to water in classroom;
- 8 plastic pint cups with 100ml water in them;
- 8 white cereal bowls;
- stop watch, stop clock or 90 second timer/sand clock;
- 8 laminated OPALometers and clarity tables;
- a copy of the challenge test log;
- pen;
- prizes and certificates.

Test rig working drawing

Piece	No. of	Length	Width	Depth	Material
1	1	800mm	300mm	18mm	Pine shelf or furniture panel
2	1	500mm	111mm	45mm	Roundline guttering
3	2				Roundline gutter bracket
4	2	260mm	200mm		Large shelf bracket
5	8				Wood screws



Water Cleaning pre task slides

https://www.flickr.com/people/aquamech-utah/

https://upload.wikimedia.org/wikipedia/commons/8/83/Newtown_Creek_Nature_Walk_-_Digester_Eggs_and_Whale_Creek..jpg

Exploring Engineering Challenge

Today you are going to be Engineers!

ROCHESTER BRIDGE TRUST

Civil Engineers – Make My Day!

Civil Engineers design:	But not these:
Stations	Trains, signals or tracks
Roads, tunnels and bridges	Cars, lorries or bikes
Airports	Planes
Water treatment plants	Taps/toilets
Harbours	Boats
Flats and large structures	Houses

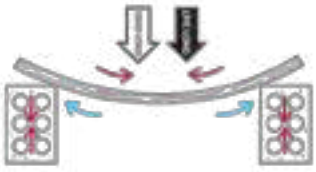
Water Cleaning pre task slides

Team Roles for Engineers

Science, design, maths, teamwork, creativity, geography and problem-solving, working together:

Architect – how the new design will look
Structural Engineer – how it will be made
Materials Engineer – what it will be made from
Value Engineer – which design is best value, based on criteria

Issues for Engineers – Forces and Loads

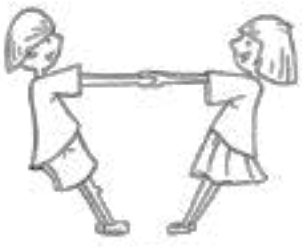


Forces in a beam bridge

Image: BalfourBeatty/Connect Plus

Water Cleaning pre task slides

Tension and Compression



Tension
Stretching Force

Compression
Squashing Force

ROCHESTER BRIDGE TRUST

Pre-Task 1a:

Material Engineers, are you ready?

ROCHESTER BRIDGE TRUST

Water Cleaning pre task slides

Pre-Task 1a:
Test, like material engineers

Material:	How could we join these materials together?	How well did this joining method work?	How might we make it stronger?
Thin card			
Thicker card			
Candy floss stick			

Joining equipment to choose from:
rubber band, cable ties, string, double sided tape

Challenge 1b:
Structural Engineers

How might we join these materials together?

How well did this joining method work?

How could we make the material stronger

Use the materials provided to make the tallest tower.
Structural Engineers make a tower...Go!

Water Cleaning pre task slides

Structures which hold dense materials

ROCHESTER BRIDGE TRUST

Civil Engineers – Make My Day!

Civil Engineers design:	But not these:
Stations	Trains, signals or tracks
Roads, tunnels and bridges	Cars, lorries or bikes
Airports	Planes
Water treatment plants	Taps/toilets
Harbours	Boats
Flats and large structures	Houses

ROCHESTER BRIDGE TRUST

Water Cleaning pre task slides

Types of water

Waste Water

Clean Water

Cleaning water

Waste Water

1 Screened with 6mm mesh

2 Settlement – big particles sink to the bottom

3 Cleaned biologically with good bacteria and more settlement

4 Treating the sludge left behind

Clean Water

1 Naturally screened.
Then, screened with 6mm mesh

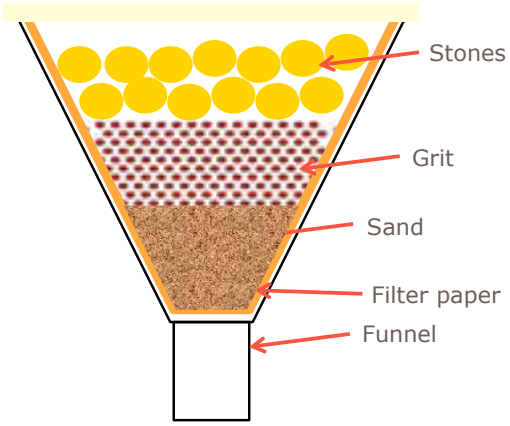
2 Settlement – big particles sink to the bottom

3 Filtered through gravel and sand

4 Disinfected and pH of the water balanced

Water Cleaning pre task slides

Effective water filtering



ROCHESTER BRIDGE TRUST

Pre-Task 2:
Design a water filter

1. Use the materials on your table:
2. Sand, grit, stones, coffee filter paper and funnel
3. Put the materials in the right order from the bottom up – coffee filter, sand, grit, then stones.
4. Predict how well your filter will work with this amount of each material. What about the speed the water flows at and how well it cleans?

ROCHESTER BRIDGE TRUST

Water Cleaning pre task slides

Pre-Task 2:

Design a water filter

1. 1 dessert spoon of each
2. 1 dessert spoon stones, 1 grit, 2 sand
3. 1 dessert spoon stone, 2 grit, 2 sand
4. 2 dessert spoons of each
5. 2 dessert spoons stones, 1 grit, 2 sand
6. 2 dessert spoons stones, 2 grit, 1 sand
7. 2 dessert spoons stones, 1 grit, 1 sand
8. 3 dessert spoons stones, 3 grit, 3 sand

Think, like Engineers - Prediction

1. What do you think will happen?
2. Test and see what happens.
3. Was your prediction right?

Water Cleaning pre task slides

Evaluate, like Engineers

What surprised you?

What seems to be the better balance of different materials for making the filter?

Work together, like Engineers

Get together with another team and compare findings

Joining materials

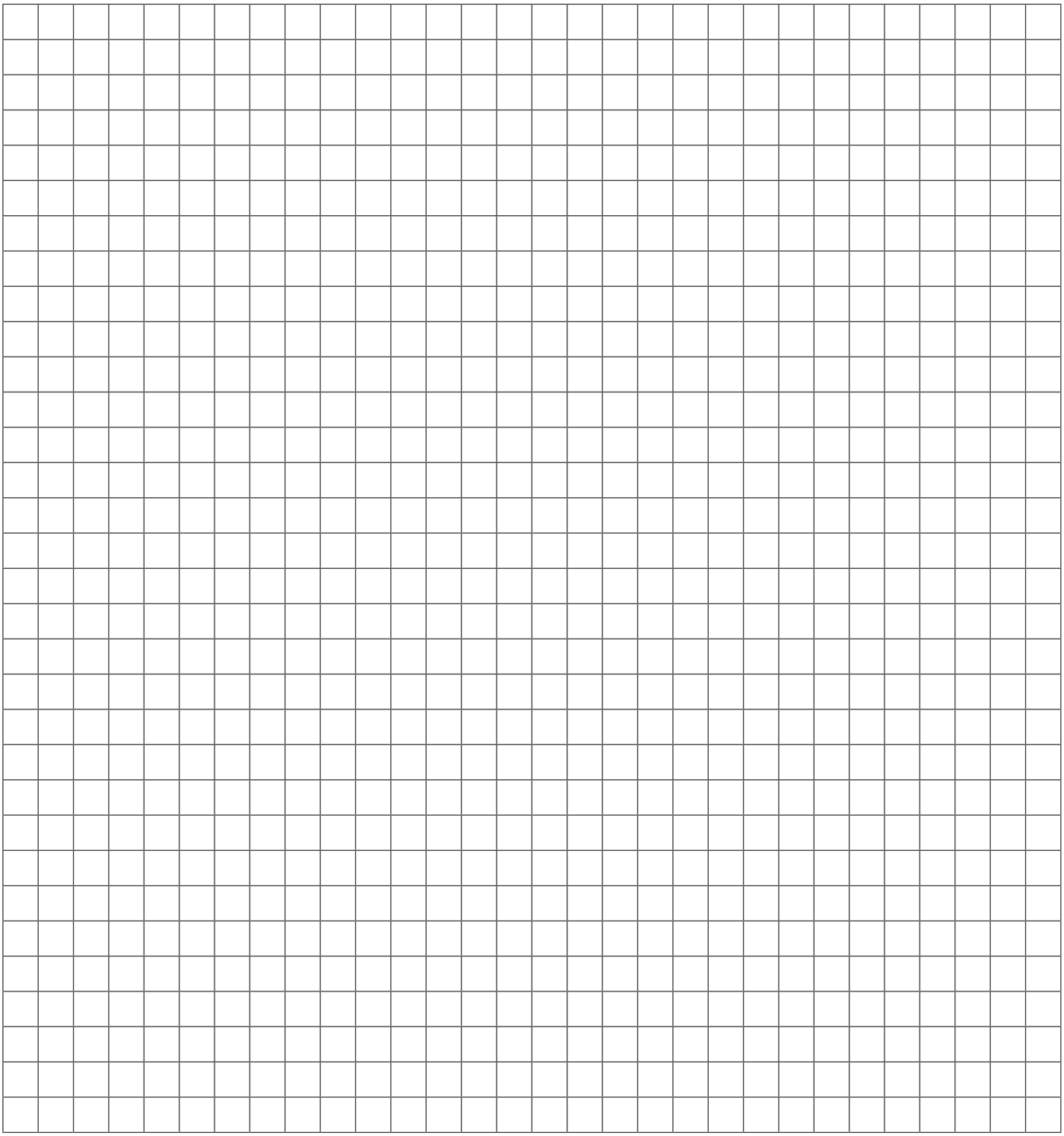
Material	How could we join these materials together?	How well did this joining method work?	How could we make it stronger?
Thin card			
Thicker card			
Candy floss stick			

Joining equipment to choose from:

Rubber band, cable ties, string, double sided tape

Practise using the double sided tape as it's designed to be used - in between materials rather than wrapped around the outside of materials.

6mm mesh



6mm mesh, used to screen water at the start of purification process

Team cards

Team 1:
1 dessert spoon of stones, 1 dessert spoon of grit, 1 dessert spoon of sand

Team 2:
1 dessert spoon stones, 1 dessert spoon grit, 2 dessert spoon sand

Team 3:
1 dessert spoon stones, 2 dessert spoons grit, 2 dessert spoons sand

Team 4:
2 dessert spoons of stones, 2 dessert spoons of grit, 2 dessert spoons of sand

Team 5:
2 dessert spoons stones, 1 dessert spoon grit, 2 dessert spoons sand

Team 6:
2 dessert spoons stones, 2 dessert spoons grit, 1 dessert spoon sand

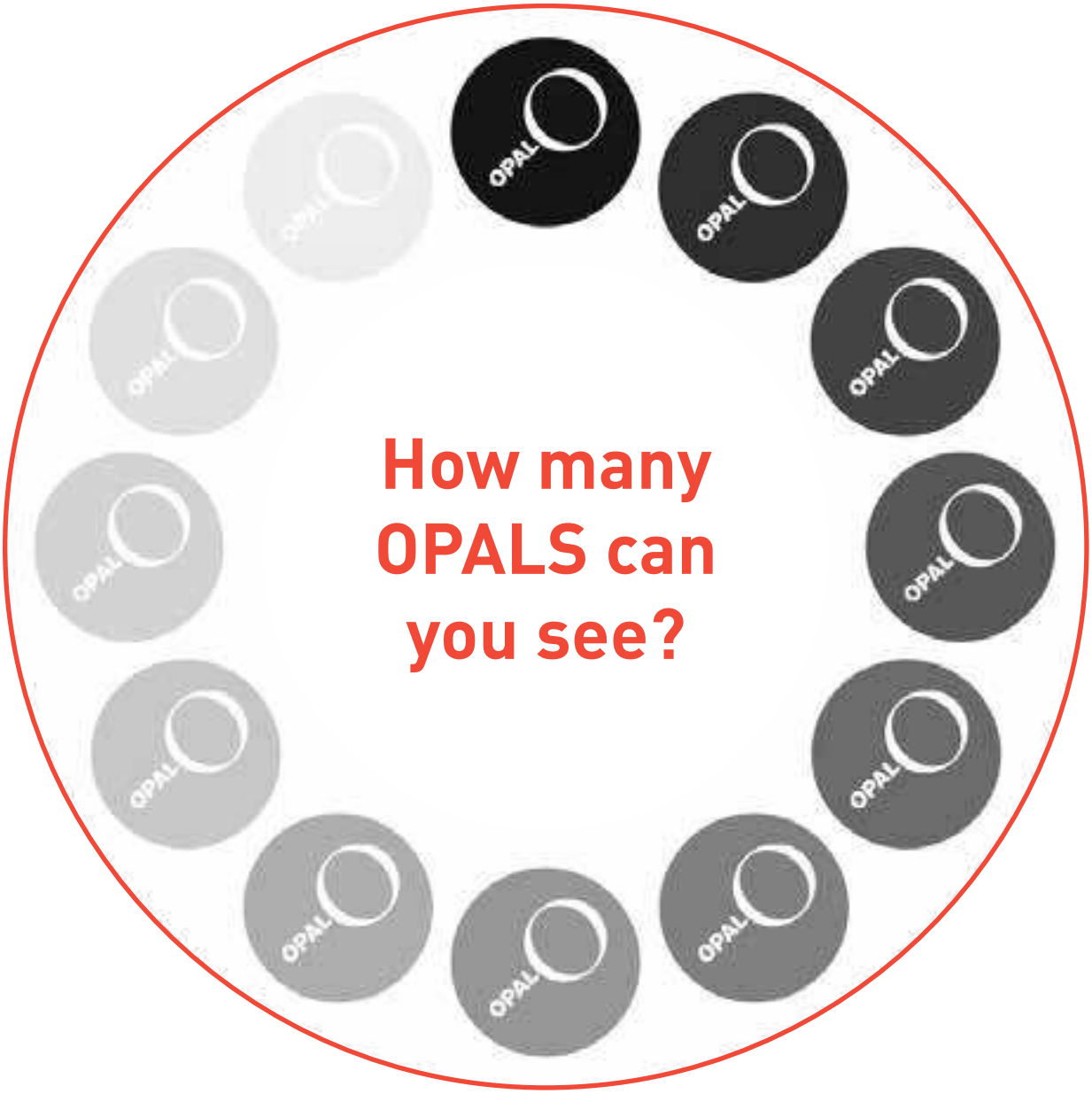
Team 7:
2 dessert spoons stones, 1 dessert spoon grit, 1 dessert spoon sand

Team 8:
3 dessert spoons stones, 3 dessert spoons grit, 3 dessert spoons sand

Measuring water clarity

Number of Opals counted	Water clarity
0 - 3	Poor
4 - 9	Average
9 +	Very good

OPALometer



OPALometer

The OPALometer (Water Clarity Measurer) How it works and what it can tell you about a pond or lake

Water clarity is a measure of how far light penetrates into water. This depends on particles suspended in the water and dissolved substances.

High water clarity means more light can reach a greater depth in a lake or pond which is good for aquatic plants. A healthy population of plants is good for the animals living in the water and the health of the water body.

Low water clarity can be caused by suspended sediment and soil washed into the lake, high concentrations of algae feeding on nutrients in the water or significant amounts of dissolved substances. Some lakes have naturally high or low water clarity. Plants and animals are affected in lakes when water clarity changes.

Common particles suspended in pond and lake water include:

- Small mineral grains (silt) and clay particles
- Dead vegetable matter
- Algae (phytoplankton) and animals (zooplankton)

Common dissolved substance in lakes and ponds:

- Organic carbon

What your results mean

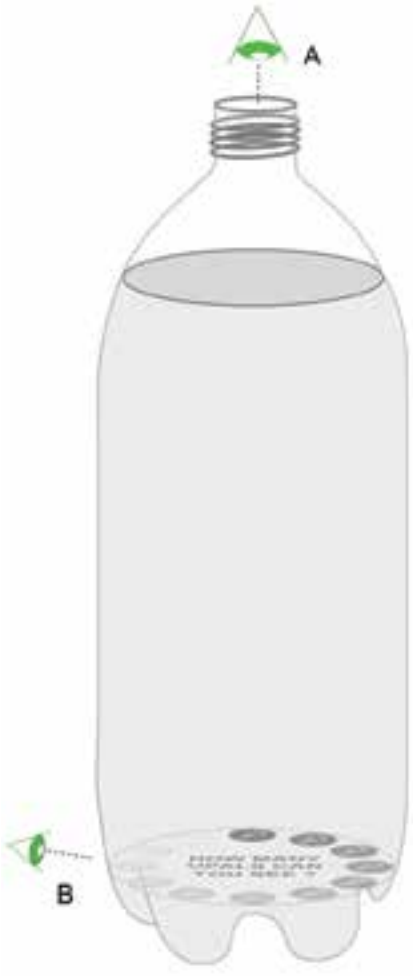
The OPALometer shows the OPAL logo in a scale of decreasing blackness (100% to 20%, 15%, 10%, 5%). It is more difficult to see the lighter OPALs when there is a higher amount of suspended particles and dissolved substances in the water. You can see how effectively light is scattered and absorbed in lake water in this way if you compare what you see when you look in the top (A, right) and from the side (B, right).

We have been comparing OPALometer readings with measurements of suspended solids, dissolved organic carbon and chlorophyll carried out by the OPAL Water Centre over the last two years. This will allow us to interpret results we receive from the OPAL Water Survey.

How to use the OPALometer

Print out this sheet and cut out the disc (left). Laminate it or cover in clear plastic tape. Tape a 1p coin to the back of the disc, roll it up and push through the neck of an empty clear 2 litre drinks bottle. Fill the bottle with water from the pond or lake to the height of an A4 sheet of paper. Look in the top of the bottle (A, above) and count the number of OPAL logos you can see.

Count the OPALs from here



Pre task 2
Water filter test log

	Number of opals counted	Volume of water collected in 90 seconds
Team 1: 1 dessert spoon of stones, 1 dessert spoon of grit, 1 dessert spoon of sand		
Team 2: 1 dessert spoon stones, 1 dessert spoon grit, 2 dessert spoon sand		
Team 3: 1 dessert spoon stones, 2 dessert spoons grit, 2 dessert spoons sand		
Team 4: 2 dessert spoons of stones, 2 dessert spoons of grit, 2 dessert spoons of sand		
Team 5: 2 dessert spoons stones, 1 dessert spoon grit, 2 dessert spoons sand		
Team 6: 2 dessert spoons stones, 2 dessert spoons grit, 1 dessert spoon sand		
Team 7: 2 dessert spoons stones, 1 dessert spoon grit, 1 dessert spoon sand		
Team 8: 3 dessert spoons stones, 3 dessert spoons grit, 3 dessert spoons sand		

Water Cleaning Challenge Slides

Water Cleaning
Exploring
Engineering
Challenge

Are you ready?

ROCHESTER
BRIDGE TRUST

Context

You are members of a team of **environmental civil engineers** working for Rochester Bridge Trust.

You have been asked to **design and model** a water filter system.

Your water filter needs to be the right size and sit in the right place for the water to be collected in one place and then travel to be used in another place.

Water Cleaning Challenge Slides

Brief

Your challenge is to design, scale model and test a water filter system which will release its water 20cm above the ground (2 metres in real life) and fit over the guttering provided. The water will then be collected and tested.

Specification

1. The water filter and structures you model must be fitted not fixed.
2. The filter must be raised to at least 20cm off the ground and be supported to sit over the left hand side of the guttering, allowing the water to flow down for collection.
3. The filter must flow quickly enough to collect sufficient water for testing in 90 seconds.
4. The water must be cleaner than it was to start with, using an Opalometer for testing.
5. The filter and its structure must promote its designers – the Rochester Bridge Trust.

(You will also get bonus points for using the materials appropriately)

Water Cleaning Challenge Slides

Testing base

The simple base has the guttering set at 20cm high on the left side and allows thin materials to slot in behind it.

Which of your materials might fit in these to create your structure?

Materials

- You have a pack of materials for making your filter and supportive structure.
- Do not use any other materials.
- You do not need to use all the materials supplied.

Water Cleaning Challenge Slides

Tools

- You are only allowed to use the tools provided.
- All cutting, and gluing must be done with great care to keep you safe.
- If you want the card scored, please see the adult who is providing this service using a cutting mat.

Materials and tools

MATERIALS:	TOOLS:
1 copy of The Challenge guidance notes 1 large funnel Cup of sand, sand, stones Coffee filter paper 2 x 1000mic grey card A3 2 x 1500mic grey card A3 1m string 6 cable ties 6 elastic bands 8 wooden kebab or candy floss sticks 1 logo	Pencils Rulers Small scissors Felt tip pens, various colours 4 sheets A4 paper for the portfolio. 1 pair large scissors 1 large hole punch Double sided tape 1 dessert spoon for measuring out 1 glue stick

Water Cleaning Challenge Slides

Your portfolio must include:

All labelled drawings.

Notes on how your team is being organised.

Notes/labels on how ideas were thought of and developed.

Notes about the challenges you have overcome.

Reasons for choosing the final design.

ROCHESTER BRIDGE TRUST

Timings for this challenge

5 mins Introduction to the Task and Testing Criteria

15 mins Planning and drawing/labelling, at least one design each

40 mins Modelling

30 mins Testing

10 mins Prizes and Certificates

ROCHESTER BRIDGE TRUST

Water Cleaning Challenge Slides

The challenge is designed to be fun!

Enjoy the challenge...

Enjoy the team work!

ROCHESTER BRIDGE TRUST

5 MINUTES LEFT!

ROCHESTER BRIDGE TRUST

Water Cleaning Challenge Slides

TOOLS DOWN!

Time to pack away

- All scrap and rubbish in the bin.
- Clear away rubbish on the floor, too.
- Spare materials and tools go into your packs in the middle of your table.
- Sit down ready for testing.

ROCHESTER BRIDGE TRUST

Testing (0,1 or 2 points for each criteria)

1. The water filter and structures fit over the guttering.
2. The filter is raised to at least 20cm off the ground and sits over the left hand side of the guttering, allowing the water to flow down for collection.
3. The filter flows quickly enough to collect sufficient water for testing in 90 seconds.
4. The water is cleaner than it was to start with, using an OPALometer.
5. The filter and its structure promote the designers from Rochester Bridge Trust.
6. BONUS: ensure double sided tape has been used correctly.

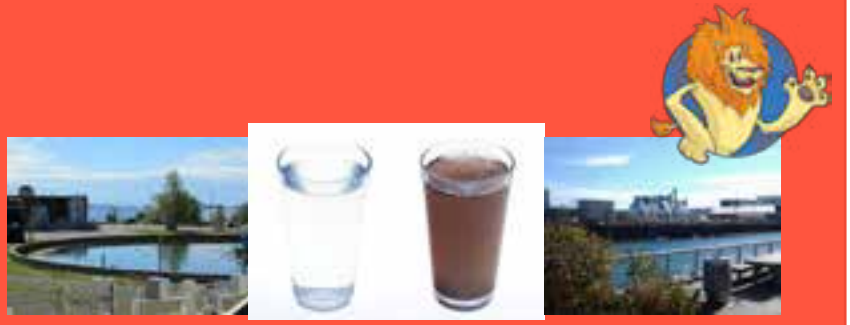
Water Cleaning Challenge Slides

ROCHESTER BRIDGE TRUST

Water Cleaning Challenge

THE RESULTS!

Are you ready?



Water Cleaning Exploring Engineering Challenge

Today you were Engineers!

Keep asking questions like why, how, what if and you can be engineers everyday!

Guidance for learners

Remember the pre tasks at the start of this Challenge, and you can look back at these notes to remind you.

Materials

- You have a pack of materials for making your filter and supporting structure.
- Do not use any other materials.
- You do not need to use all the materials supplied.

Tools

- You are only allowed to use the tools provided.
- All cutting, and gluing must be done with great care to keep you safe.
- If you want the card scored, please see the adult who is providing this service using a cutting mat.

Challenge Materials/Tools List for All Teams

Please check that you have the following materials on your table and report any shortages to your challenge leader.

Item	Quantity
Large funnel	1
Plastic cups of:	
sand	1
grit	1
small stones/pebbles	1
coffee filter paper	1
1000mic grey card A3	2
1500mic grey card A3	2
1m string	1
Cable ties	6
Elastic bands	1
Wooden kebab or candy floss sticks	8
Rochester Bridge Trust logo	1
glue stick	1
A4 sheets of paper	4

Tool List

- Pencils
- Rulers
- Small scissors
- Felt tip pens, various colours
- 1 pair large scissors
- 1 large hole punch
- Double sided tape
- Glue stick
- 2 dessert spoons for measuring out

Guidance for learners

Context

You are members of a team of Environmental Civil Engineers, working for Rochester Bridge Trust.

You have been asked to design and model a water filter system.

Your water filter needs to be the right size and sit in the right place for the water to be collected in one place and then travel to be used in another place.

Brief

Your challenge is to design, scale model and test a water filter system, which will release its water 20cm above the ground (2 metres in real life) and fit over the guttering provided. The water will then be collected and tested.

Specification

1. Your water filter and structures must be fitted not fixed over the guttering.
2. The filter must be raised to at least 20cm off the ground and be supported to sit over the left hand side of the guttering, allowing the water to flow down for collection.
3. The filter must flow quickly enough to collect sufficient water for testing in 90 seconds.
4. The water must be cleaner than it was at the start, using an OPALometer for testing.
5. The filter and its structure must promote its designers (who are the Rochester Bridge Trust).

A simple portfolio must be produced as part of your design and planning and should include:

a) all labelled drawings;

b) notes on how your team is being organised;

c) notes/labels on how ideas were thought of and developed;

d) notes about the challenges you have overcome; and

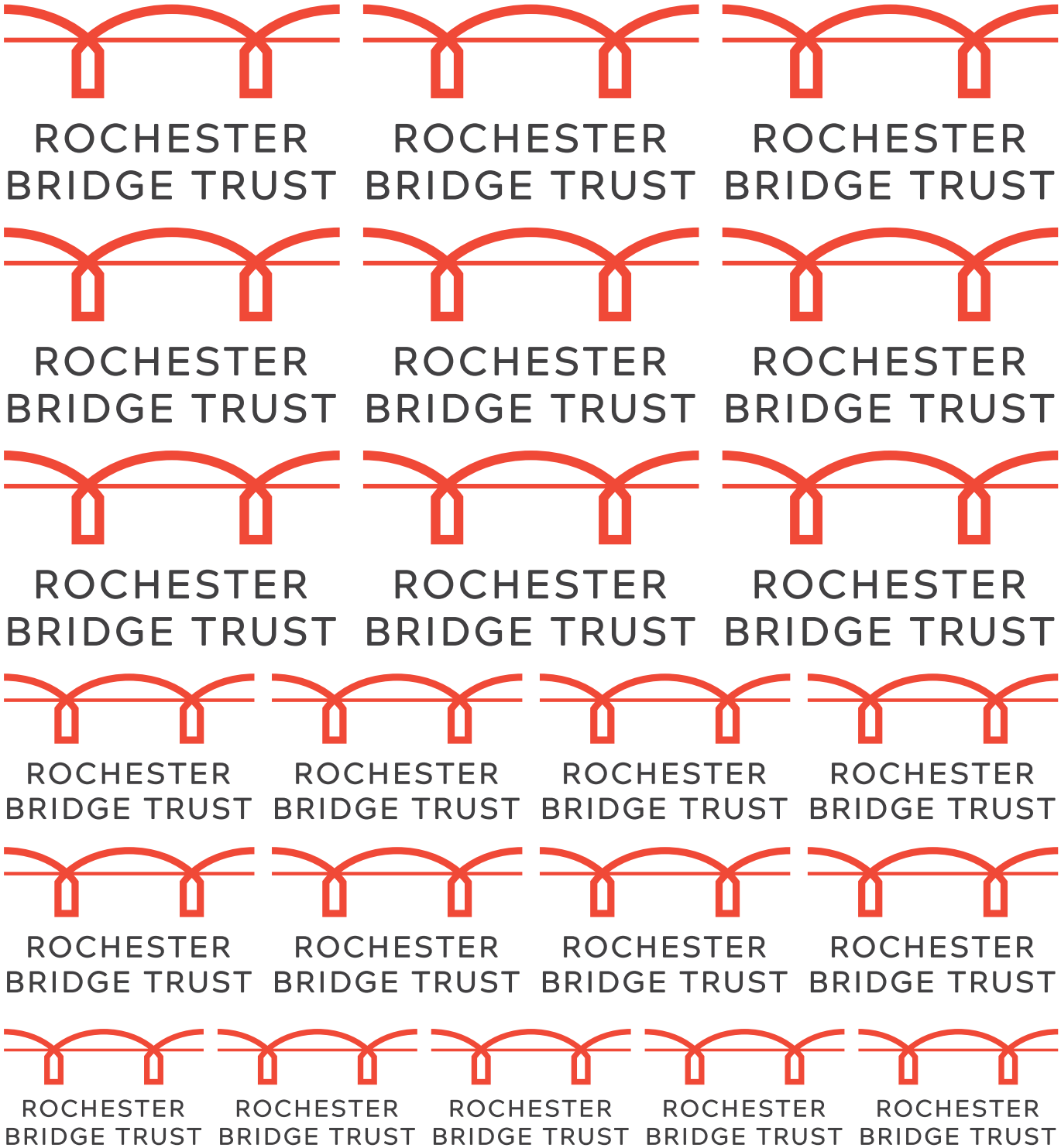
e) reasons for choosing the final design.

Inspiration from Existing Products:

Structures which hold dense materials

The day is designed to be fun! Enjoy the challenge and the teamwork.

Rochester Bridge Trust logo samples



Testing notes

The test log provides you with the six tests and space to log results for each team.

While the water is dripping through the filters, you can ask the teams:

- what surprised you as you worked together?
- what do you know now that you did not know before?

Each test is worth 0, 1 or 2 points:
0 = doesn't do this
1 = does this somewhat or just about
2 = yes, does this.

NB: for most of the tests, it will be obvious if the criterion has been met. We are trying to give points to the teams rather than trying to penalise them during each test.

When testing this design challenge, some structures did not hold the filters in the correct place, so we held them manually. This meant the team got zero points for tests 1 and 2, but could still be tested for the effectiveness of criteria 4 and 5. The logos had to be seen from the front of the room to be able to get points for test 5.

Use the pint glasses again to hold the dripping funnels after testing (perhaps somewhere behind/out of the way is best so they don't get knocked over) and the bowls of filtered water can be lined up along the front in case you want to compare them as part of the plenary.

Testing Criteria:

1. The water filter and structures fit over the guttering.
2. The filter is raised to at least 20cm off the ground and sits over the left hand side of the guttering, allowing the water to flow down for collection.
3. The filter flows quickly enough to collect sufficient water for testing in 90 seconds.
4. The water is cleaner than it was to start with, using an OPALometer.
5. The filter and its structure promote the designers from Rochester Bridge Trust.
6. **BONUS:** ensure double sided tape has been used correctly.

Test log for whole group

No = 0 Somewhat = 1 Yes = 2 points

Team names:								
The water filter and structures fit over the guttering.								
The filter is raised to at least 20cm off the ground and sits over the left hand side of the guttering, allowing the water to flow down for collection.								
The filter flows quickly enough to collect sufficient water for testing in 90 seconds.								
The water is cleaner than it was to start with, using an OPALometer.								
The filter and its structure promote the designers from Rochester Bridge Trust.								
BONUS: ensure double sided tape has been used correctly.								
Total/12								

Certificate

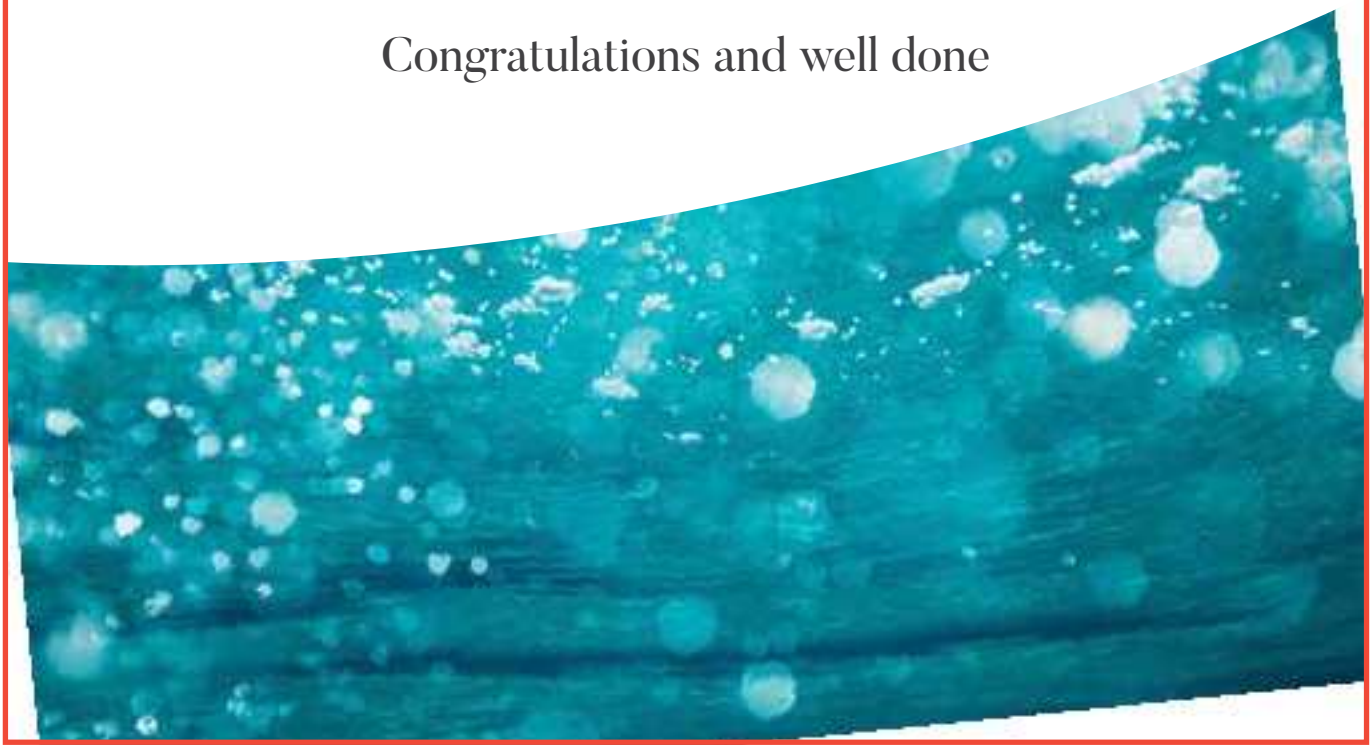
CERTIFICATE

ROCHESTER
BRIDGE TRUST

This is to certify that _____

worked hard taking the first steps to become a
Civil Engineer

Congratulations and well done



Risk assessment

Activity: Exploring Engineering Challenge – Water Cleaning **Date written:** September 2019

Brief overview of activity: Designing and Construction of small water filtration device using small craft materials and tools – FOR INFORMATION ONLY

Potential hazards?	Who might be harmed and how?	Level of risk (low/ medium/ high)	What will be done to manage this risk?	Action by whom?	Action by when?	New risk	Action plan for untoward occurences
Physical activities	Individuals – falls during pushing / pulling activity	Medium	Choose individuals of equal size. Clear demonstration area so no sharp edges. Clear safety instructions to individuals involved.			Low	Administer first-aid / call for emergency medical assistance as required
Craft activities	Learners – splinters & cuts from broken wood; cuts from using sharp implements.	Medium	Safety instructions and supervision. n.b. no carrying sharp implements around the room			Low	Administer first-aid / call for emergency medical assistance as required
Movement around space	Falls, slips, trips.	Medium	Safety instructions – walk don't run; pick up anything which falls on the floor; no carrying sharp implements around the room. Tuck chairs & bags under tables during making activities. Clear items which have fallen onto the floor asap.			Low	Administer first-aid / call for emergency medical assistance as required

Please note: this risk assessment sample is to be used as information only. You must ensure that you carry out your own full risk assessment for your particular setting and participants.

ROCHESTER
BRIDGE TRUST

Supporting engineering education

www.rochesterbridgetrust.org.uk